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Characterization of Contaminated Abattoir Soil in Swali Market, Bayelsa State

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***Abstract**: The waste effluents and waste from abattoirs have been documented to have harmful effects on the soil media, which causes threats to the living organisms and their surroundings, hence the need to characterize the contaminated abattoir soil in Swali market. Soil samples were characterized for possible contamination of physicochemical parameters and heavy metals. Six (6) soil samples were collected for six weeks at different points radially, the control was from a well of 160m from the abattoir, remaining five (5) samples were collected from various points which are 2m away from the abattoir the depth of 0.5m and 2m apart in cyclic. The soil samples were taken to the laboratory for digestion and analysis. The physicochemical parameters result showed that; pH (3.8-6.3), conductivity (56-462) µ, temperature (29) ^{O}C, TDS (38-332) ppm, SO_4 (343.32-2403.24) mg/l, HCO_3 (0.2-8.05) mm/l, D.O (5.1-6.3) mm/l, B.O.D (0.1-0.2) mm/l, Alk (75-250) mg/l, Acidity (50-755), while the result of heavy metals indicated; Pb (0.39-0.73) mg/l, Cr (0.06-0.113) mg/l, Mg (1.22-1.79) mg/l, Co (0.25-0.92) mg/l, Co (0.25-0.92) mg/l and Fe (2.13-8.45) mg/l/. The results were compared with FEPA and WHO standards and validated using ANOVA with Python 3.6 and SPSS software version 20 to compare the values of p and r^2 using different statistical models. The coefficient of determination (r^2) ranges between 0.928125 and 0.996132 per cent, which is significant. Therefore, the soil around the abattoir has been adjudged to have a high level of heavy metal contamination, indicating that the soil is polluted and does not conform to standards.*

Keywords: Soil, Abattoir, Contamination, Pollutants, Heavy Metals.

Abbreviations:
SPSS: Statistical Package for the Social Sciences
WHO: World Health Organisation
TDS: Total Dissolved Solids
CEC: Cation Exchange Capacity

I. INTRODUCTION

Soil, being a vital component of the environment, houses most of human needs. The environment encompasses the air, water, and soil; the soil, like all others, is also being polluted. The soil, being a universal sink, bears the most significant burden of environmental pollution generated by "anthropogenic" activities [1]. The lives of other valuable living organisms such as Plants, Nematodes and other higher Animals depend on the soil for survival, the alterations of soil stability via contamination bring about an imbalance in the ecosystem and nutrients for both plants and animals, in other words, contamination birth pollution as a result of injection of contaminants which negatively affects people's health, comfort, property, or environment [2]. These contaminants typically are by-products or residues from the manufacturing of anything valuable, sewage, solid waste, wastewater, accidental release, or other means as a result of natural resources [1] [3]. Similarly, Ediene et al. [4] further point out that soil contamination is commonly caused by unregulated sewage and other liquid waste discharged from domestic water use, contaminated industrial wastes, agricultural effluents, irrigation water drainage, urban runoff, and animal husbandry, from which comes the abattoir waste. The physiochemical parameters of soil can be dramatically altered by operations involving abattoir waste; lead (Pb), chromium (Cr), arsenic (As), zinc (Zn), cadmium (Cd), copper (Cu), mercury (Hg), and nickel (Ni) are among the heavy metals that are most impacted. According to Dan *et al.* and Ubwa *et al.* [5] [6], there were also reports of higher than allowed levels of trace metals in the soils of Yauri, Nigeria, which were impacted by abattoir waste. Salts, chemicals, organic and inorganic materials, blood, and fat are commonly found in abattoir waste [7] [3]. Cellulose fibre makes up most of the undigested food in the faeces of livestock animals. Other food items that are present include undigested protein, excess nitrogen from protein digestion, leftovers from fluid digestion, waste mineral matter, bacteria, mucus, and worn-out intestinal lining cells. Foreign matter, such as uncleaned calcium, magnesium, iron, phosphorus, and sodium, is also present. Globally, a range of efforts have identified that abattoir wastes are sources of environmental damage [8], and they raise the pH of the soil, which in turn causes a decline in crop growth and yield [9]. The effects of human contact with contaminated soils are found in many animal parts, such as flesh, blood, liver, kidney, innards, and hair [10].

Despite the facility's small size, the Swali Market abattoir generates waste that is not adequately managed or treated, affecting the physicochemical parameters and heavy metal levels of the soil surrounding the abattoir in Bayelsa State. Since the soil is a natural resource that bears the brunt of environmental pollutants, it is essential to prevent soil contamination to maintain soil fertility and boost productivity. The information gathered will be used to describe the soil conditions in the abattoir and to determine the level of each contaminant in comparison to the stated standards.

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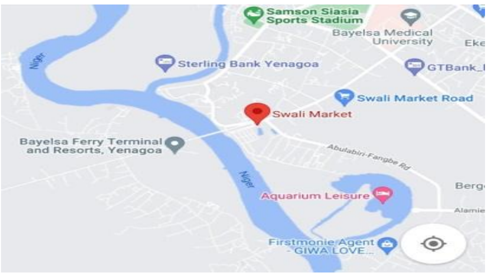
II. MATERIALS AND METHODS

A. Study Area

The contaminated soils from the abattoir in Swail Market (Fig. 1) were used in investigating the contamination rate of animal waste on soil. The abattoir within the Swali market, Yenegoa, Bayelsa State, is located uphill just beside River Nun (Plate 1). The river is the primary source of water for abattoir activities, which have started within the watershed. At the abattoir site, an average of 10 – 15 cows and other animals are slaughtered daily, which generates waste like bones and cow dung, etc., and can be seen close to the riverbank and on the soil around the abattoir that is in Sawli Market.



[Fig.1: Location of Swali Market in Yenegoa]

[Fig.2: Plate Swali Abattoir Market]

B. Sample Collection

Six (6) soil samples were collected for six weeks at different points radially from the vicinity of the abattoir. One sample was obtained from around a well situated 160m from the slaughterhouse, identified as the control. The remaining five (5) samples were obtained within a depth of 0.5m at 2m away from the slaughter slab and 2m apart from each collection point in a circular form. The samples were collected at 9:00 a.m. every Monday for six consecutive weeks, during the dry season. The top layer of the soil was first excavated before the trowel was used to dig out the contaminated soil, which was then placed on a rubber plate. This process was repeated at all six sampling points. Samples were then dried in air, crushed, and sieved through a 2mm diameter mesh. They were kept in clean polythene bags and labelled appropriately before being stored at room temperature for laboratory analysis.

C. Determination of Physicochemical Parameters

The physicochemical parameters of the soil samples were determined using standard methods for soil analysis, as outlined by Udo and Ogunwale [11] [12], by the Association of Official Analytical Chemists. A crushed part of the air-dried soil sample was completely mixed with water in a ratio of 1:1 by volume. A JENWAY 3015 pH/conductivity meter was utilized to determine the pH and electrical conductivity of the soil. The physiochemical parameters included. pH, conductivity, temperature, TDS, SO_4, HCO_3, D.O, B.O.D, Alkanity, Acidity.

The heavy metal analysis was carried out using hydrochloric acid digestion, and metal ion concentrations were determined using an atomic absorption spectrometer (model Philips PU 9100) with a hollow cathode lamp and a fuel flame (air-acetylene). The parameters for chromium, cobalt, cadmium, iron, and lead analysis were as follows.

D. Analysis of Variances (ANOVA)

To determine the differences among the means of contaminants tested and the variation with each sample collected, relative to the amount of variation between the samples, analysis of variance was used using the Statistical Package for the Social Sciences (SPSS) version 20 and Python 3.6 for all physicochemical parameters tested. Still, for Heavy metals, only SPSS was used in determining the mean standard deviation (M±SD). Confident level of determination (P=0.05).

III. RESULTS AND DISCUSSION

Table-I: Analysis of Physicochemical Parameters of Abattoir Contaminated Soil at Swail Market Point A

Samples	pH	Conductivity	Temperature	TDS	SO_4	HCO_3	D.O	B. O. D	Alkalinity	Acidity
Week 1	3.8	462	29	332	343.32	1.45	5.5	0.2	75	75
Week 2	5.4	64	29	45	2403.24	0.2	5.2	0.1	125	52
Week 3	6.1	73	29	52	1030.00	8.05	6.3	0.2	250	75
Week 4	6.2	60	29	41	1544.94	1.3	5.4	0.2	150	755
Week 5	6.3	56	29	38	1030.00	1.30	5.1	0.1	125	50
Week 6	8.1	857	29	32	173	1.6	5.2	0.2	125	75

All parameters are in (mg/L-1) except for pH, no unit, and conductivity, which is in (µS cm), while the temperature is in ^{O}C

Table-II: Analysis of Physicochemical Parameters of Abattoir Contaminated Soil at Swail Market Point B

Samples	pH	Conductivity	temperature	TDS	SO_4	HCO_3	D.O	B. O. D	Alkalinity	Acidity
Week 1	4.0	464	29	336	345.32	1.47	7.5	0.4	77	77
Week 2	5.6	68	29	47	2405.24	0.4	7.2	0.3	128	54
Week 3	6.3	75	29	55	1032.00	8.07	8.3	0.4	252	77
Week 4	6.4	62	29	43	1546.94	1.7	7.4	0.4	152	757
Week 5	6.5	58	29	40	1032.00	1.50	9.1	0.3	128	52
Week 6	8.3	859	29	36	175	1.8	7.2	0.4	127	77

All parameters are in (mgL^{-1}) except for pH, no unit, and conductivity, which is in (µS cm), while the temperature is in ^{O}C.

Table-III: Analysis of Physicochemical Parameters of Abattoir Contaminated Soil at Swail Market Point C

Samples	pH	conductivity	temperature	TDS	SO_4	HCO_3	D.O	B. O. D	Alkalinity	Acidity
Week 1	3.6	460	29	330	341.32	1.43	5.3	0.1	73	73
Week 2	5.2	62	29	43	2401.24	0.10	5.0	0.1	123	50
Week 3	5.9	71	29	50	1032.00	8.03	6.1	0.1	230	71
Week 4	6.0	58	29	39	1542.94	1.10	5.2	0.1	130	752
Week 5	6.1	54	29	36	1032.00	0.90	4.9	0.1	123	48
Week 6	7.9	855	29	30	171	1.40	5.0	0.1	123	73

All parameters are in (mgL^{-1}) except for pH, no unit, and conductivity, which is in ($\mu S\ cm^{-1}$), while the temperature is in ^{O}C

Table-IV: Analysis of physicochemical parameters of Abattoir contaminated soil at Swail Market Point D

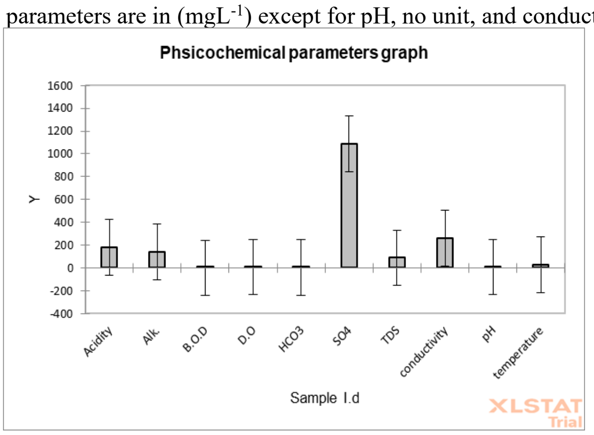
Samples	pH	conductivity	temperature	TDS	SO_4	HCO_3	D.O	B. O. D	Alkalinity	Acidity
Week 1	4.2	466	29	338	347.32	1.49	7.7	0.6	79	79
Week 2	5.8	70	29	49	2407.24	0.6	7.5	0.5	132	56
Week 3	6.5	77	29	57	1034.00	8.09	8.5	0.6	254	79
Week 4	6.6	64	29	45	1548.94	1.9	7.6	0.6	154	759
Week 5	6.7	60	29	42	1037.00	1.52	9.3	0.5	130	54
Week 6	8.5	861	29	38	177	2.0	7.4	0.6	129	79

All parameters are in (mg/L-1) except for pH, no unit, and conductivity, which is in (µS cm), while the temperature is in ^{O}C

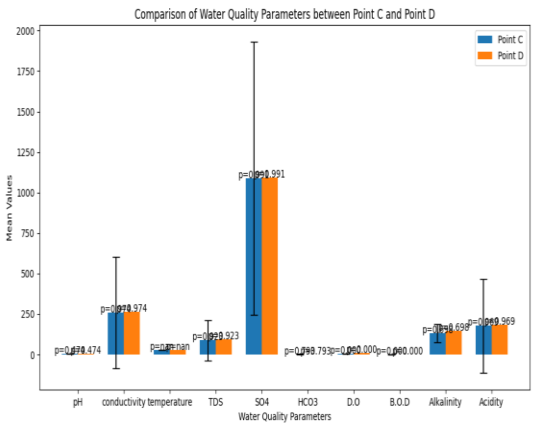
Table-V: Analysis of Physicochemical Parameters of Abattoir Contaminated Soil at Swail Market Point E

Samples	pH	conductivity	temperature	TDS	SO_4	HCO_3	D.O	B. O. D	Alkalinity	Acidity
Week 1	3.2	440	29	310	339.32	1.41	5.1	0.1	71	71
Week 2	5.0	60	29	41	2399.24	0.10	4.8	0.2	121	48
Week 3	5.7	69	29	48	1030.00	8.01	5.9	0.1	210	69
Week 4	5.8	56	29	37	1540.94	1.00	5.0	0.2	128	750
Week 5	5.9	52	29	34	1030.00	0.70	4.7	0.1	121	46
Week 6	7.7	853	29	28	169	1.20	4.8	0.2	121	71

All parameters are in (mgL^{-1}) except for pH, no unit, and conductivity, which is in (µS cm), while the temperature is in ^{O}C.

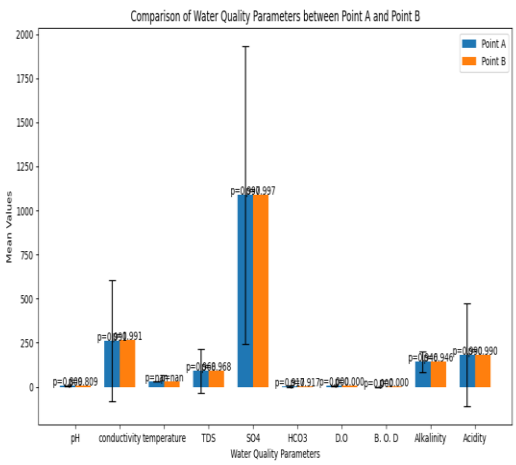


[Fig.3: Analysis of Variances for Physicochemical Parameters at P-Values of 0.05 Using SPSS Version 20, (Mean Value)]



Contaminated soil parameters

[Fig.5: Analysis of Variances for Physicochemical Parameters at P-Values of 0.05 using Python 3.6 (Point C and D)]



Contaminated soil parameters

[Fig.4: Analysis of Variances for Physicochemical Parameters at P-Values of 0.05 using Python 3.6 (Point A and B)]

A. Data Analysis of Physicochemical Parameters

The results in tables 1-5 show the laboratory analysis of soil samples collected from the abattoir market in Swail. The weekly analysis revealed that the pH levels for the samples range from 3.2 to 8.5, with significant variations between each other. Although most of the pH values fell within the WHO maximum permitted standard range of (6.5-8.5), most of the samples taken in week 1 showed lower pH values that ranged from (3.2-4.2), which conformed to Okwakpam et al., and Rabah et al. [13] [14]. This can result in undesirable ailments, such as acidosis [15], which can be attributed to waste products like dung, blood, fat, intestines, and urine, all of which are indicators of an abattoir that reduce anaerobic activities. Furthermore, Idisi and Uguru [16] stated that the lower the pH, the higher the

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heavy and toxic metals within any medium. The temperature of soil depends on the ratio of energy absorbed in the soil; soil temperatures range between -20 to 60 C This is the most important property because it shows its effect on the chemical, physical, and biological processes related to the growth of plants. The temperature for all days is 29°C, which is normal and remains constant throughout the period. No significant difference was recorded. The electrical conductivity determines the amount of pollutant in the soil. From the tables, the amount of electrical conductivity ranges from (52-861) µS cm^{-1}, results varied significantly from each other, although the values fell within the WHO maximum permitted standard limits 0f 1000 µS cm^{-1}. The values obtained were not in line with a similar study, whose values range within (80-110) µS cm^{-1} [17]. The results of weeks 1 and 6 tend to be higher when compared with others. Increases could be ascribed to the buildup of wastes such as bones, hairs, flesh, and blood salts in abattoir effluents between the soil openings [9] (Radha, 2011). The observation of higher levels of electrical conductivity in abattoir soils than in the control soil could be ascribed to the low cation exchange capacity (CEC) of the control soil and variations in the rates at which metallic salts and organic matter complexes are formed [5]. The total dissolved solids (TDS) range from 28 to 338 mg/kg, which is within the World Health Organisation (WHO) limits of < 600 mg/kg. Similarly, Igbinosa and Uwidia [18] reported TDS levels of 330 mg/kg and above, indicating that the higher the soluble salt content of a liquid, the higher its dissolved solute concentration. This is a result of blood effluent, which is higher in salts, and cattle faeces, which contain a negligible number of salts.

The dissolved oxygen is responsible for microorganisms to survive in that environment; it is mainly the amount of oxygen present in the soil that the microorganisms living there will utilise, and it is supposed to be no more than 10 mg/kg. The dissolved oxygen values varied between (4.3-9.3) mg/kg from the analysed result; all the samples recorded dissolved oxygen values that range within the acceptable limit of the WHO standard (5-10) mg/kg. Which means it is well saturated. Biochemical oxygen demand is a measure of the quantity of oxygen consumed by microorganisms during the decomposition of organic matter. BOD and COD concentrations in contaminated soil are essential, as they are significant environmental concerns [19]. In Tables 1-5, the BOD values range from 0.1 to 0.6 mg/kg, which is within the recommended standards of the WHO. This indicates that the soil is well saturated, as the DO is high. Across tables 1-5, the values of alkalinity fell in a range of (73-254) mg/kg, with the total concentration values on average more than the WHO permissible limit of 120mg/kg, indicating that the soil is alkaline. Alkalinity is a measure of the ability of water to neutralise acids, and it mainly occurs due to the presence of carbonates and bicarbonates in the soil. The results in Tables 1-5 varied significantly from each other, although the values did not fall within the WHO limits. The very high values of sulphate found in the vicinity of the abattoir could be attributed to the increased microbial activities due to the large deposits of animal waste [10]. It has been reported that uptake in plants is not affected by the additional intensification of sulphate concentration. However, plant development can have effects on crop production, especially if it exceeds the permissible limits. Bicarbonate is a product of the hardness of the water that pollutes the soil its results revealed that the values of bicarbonate ranged between (0.2-8.07) mg/kg while the acidity content fell within the range of (46-757) mg/kg, the high content shows that the soil alkaline is low at the point of sampling.

B. Interpretation of Variance Analysis for Contaminated Soil (Physicochemical Parameters)

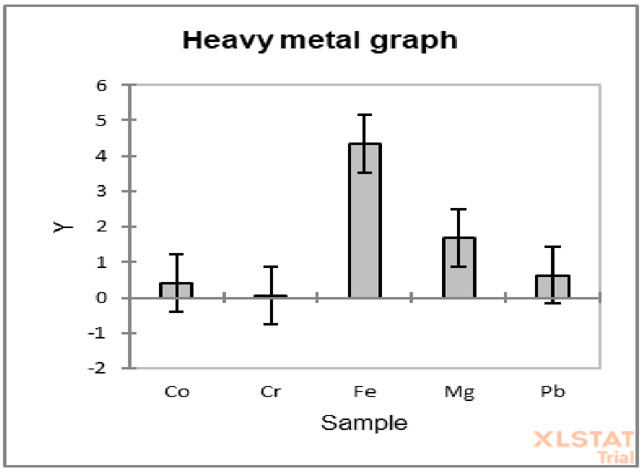
The variance analysis for physicochemical parameters using SPSS shows that only acidity, alkalinity, SO4, and conductivity are within the range of $P \geq 0.05$, a significant level. In contrast, the results for pH, temperature, TDS, HCO3, and DO are not substantial. BOD, the p-value is $P \leq 0.05$, a considerable level indicating that the null hypothesis is true. The assertion that the abattoir waste contaminates the soil is true, as those parameters were above the critical level at 0.09-0.90. For those values with low P-values less than 0.05, the null hypothesis is rejected, and it can be deduced that the contaminant data are either insufficient to confirm the contaminated level or the abattoir contamination level is less than that of the contaminants—analysis of Heavy Metals in Contaminated Abattoir Soil.

Table-VI: Mean Values of Heavy Metals Contaminated Soil Within the Abattoir in the Swali Market

Sample	Pb	Cr	Mg	Co	Fe
Week 1	0.7	0.49	1.69	0.25	3.44
Week 2	0.39	0.09	1.79	0.41	3.8
Week 3	0.65	0.077	2.28	0.92	8.45
Week 4	0.73	0.066	1.79	0.44	6.59
Week 5	0.64	0.06	1.75	0.33	2.9
Week 6	0.6	0.58	1.65	0.32	2.5
Control	0.61	0.139	1.221	0.14	3.14

Note: all parameters are in mg/L

Table 6 above reflects the mean value of the amount of heavy metal in the analysed contaminated soil taken from Swail at various points over 6 weeks, along with the control values. The values of lead range between (0.39-0.73) mg/L, which is above the WHO permissible limits of 0.015mg/l. The lead values were higher than the values from the study carried out by Igbinosa and Uwidia [20]. Lead is found in bones, blood vessels, and other internal organs. The human body will be absorbed through the consumption of food, groundwater, and air. The value of chromium ranged between (0.06-0.113) mg/L, which is above the WHO permissible limits of 0.05mg/L. The pollution of soil by chromium could be due to exposure to wastes from chromate processing facilities that are improperly disposed of in open dumps. Incidentally, there is a landfill very close to the abattoir where the bones are disposed of. The harmful effects of chromium on humans are primarily associated with its hexavalent form. Chromium's harmfulness includes liver necrosis and membrane ulcers, and it is responsible for dermatitis when it meets the skin [21]. Magnesium is a nutritional component for human beings. One of the elements responsible for the functioning of the membrane is stimulation for the transmission of nerve impulses, muscle contraction, and DNA replication [22]. The permissible limit set by the WHO is 50 mg/L, and the magnesium levels in the soil range between 1.22 and 1.79 mg/L, which is lower compared to the standard. However, it has been reported that high magnesium levels can result in water hardness [10]. The cobalt values ranged between 0.14 and 0.92 mg/L. According to the WHO, the acceptable limit for cobalt in soil ranges between 0.2 and 0.5 mg/L. From Table 6, at week 3, there was an increase in Co above the acceptable limit, while other sampled values remained within the limit. Iron is the most abundant and most essential constituent for all plants and animals. On the one hand, at high concentrations, it causes tissue damage and some other diseases in humans. It is also responsible for anaemia and neurodegenerative conditions in human beings [23]. As shown in Table 6, the result indicates that soil samples contained Fe in the concentration range of 2.90-8.45mg/L, iron, according to WHO standards, has a limit of 0.3mg/l for consumption. The results in Table 6 for iron indicate that the soil is heavily contaminated with iron.



[Fig.6: Analysis of Variances for Heavy Metals Parameters at P-Values of 0.05 using SPSS Version 20 (Mean Value)]

Table-VII: Analysis of Variances for Contaminated Soil Within Abattoir in the Swail Market with Mean Values and P-Values

Elements	Mean value	P value	r^2
Pb	0.63429	0.088178	0.928125
Cr	0.13786	0.123452	0.945000
Mg	1.67729	0.598779	0.953421
Co	0.40857	0.778433	0.996132
Fe	4.30571	0.212601	0.949632

C. Interpretation of Variance Analysis for Contaminated Soil (Heavy Metals)

Table 7 and Fig. 4 above present the analysis of variance for heavy metals using SPSS. The P-values range from 0.088178 to 0.778433 for all parameters considered. Since all the values are above the significance level of 0.05, it can be inferred that the contaminated soils contain high levels of heavy metals, which are harmful to humans, animals, and plants. The coefficient of determination (r^2) ranges between 0.928125 and 0.996132 per cent, which is significant. Therefore, the soil around the abattoir has been adjudged to have a high level of heavy metal contamination, indicating that the soil is polluted and does not conform to standards.

IV. CONCLUSION

The ever-growing human and animal populations depend directly or indirectly on the products of the soil. The soil is a universal sink, bearing the most significant burden of environmental pollution generated by "anthropogenic" activities, of which the abattoir is a part. Much of the existing research on abattoir waste has focused on water contamination; thus, this study, among the few, examines the extent to which an abattoir contaminates the soil. It had been revealed that the soil in the Swail abattoir market is heavily polluted with heavy metals at a significant level of P-values ranging from (0.088178-0.778433), which is below the threshold of 0.05. The coefficient of determination (r^2) also varies between 0.928125 and 0.996132, which may have resulted from anthropogenic activities such as the use of rubber tires to burn or stream meat, as well as the burning of animal skin. The tested physicochemical parameters are mostly not in conformity with the World Health Organisation (WHO) standards.

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DECLARATION STATEMENT

I must verify the accuracy of the following information as the article's author.

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- **Funding Support:** This article has not been funded by any organizations or agencies. This independence ensures that the research is conducted with objectivity and without any external influence.
- **Ethical Approval and Consent to Participate:** The content of this article does not necessitate ethical approval or consent to participate with supporting documentation.
- **Data Access Statement and Material Availability:** The adequate resources of this article are publicly accessible.
- **Author's Contributions:** The authorship of this article is contributed solely.

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